

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
16 September 2004 (16.09.2004)

PCT

(10) International Publication Number  
**WO 2004/079985 A1**

(51) International Patent Classification<sup>7</sup>: **H04L 9/06**,  
12/28, 12/56

(21) International Application Number:  
PCT/EP2004/002307

(22) International Filing Date: 5 March 2004 (05.03.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
RM2003A000100 6 March 2003 (06.03.2003) IT

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Declaration under Rule 4.17:**

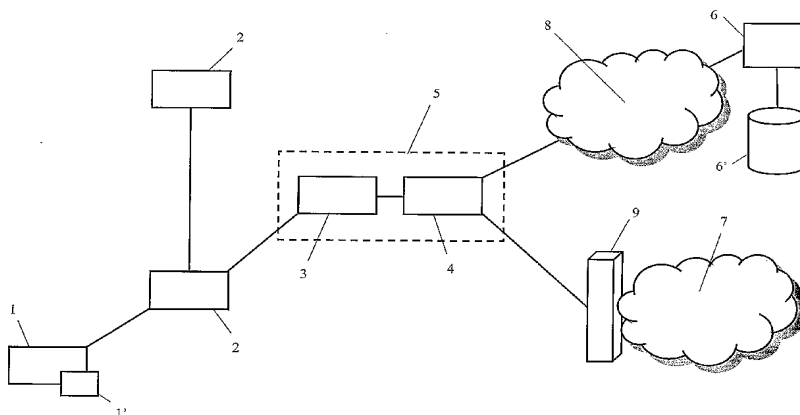
— of inventorship (Rule 4.17(iv)) for US only

**Published:**

— with international search report  
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

[Continued on next page]

(54) Title: METHOD AND SOFTWARE PROGRAM PRODUCT FOR MUTUAL AUTHENTICATION IN A COMMUNICATIONS NETWORK



(57) Abstract: A method for mutual authentication between a subscriber and a communications network, in which a random number is generated at the subscriber's terminal (1, 1'). The random number is sent to the authentication sub-system (6, 6') managing the authentication of the subscriber for the access to the network, e.g. together with a subscriber's identifier. At the authentication sub-system, the identifier is used for checking the credentials of the subscriber. During the authentication process, parameters related to the subscriber's identifier are generated at the authentication sub-system, and the random number is encrypted using a session key formed using such parameters. The encrypted random number is then sent back to the subscriber's terminal, together with information needed to terminal in order to reconstruct the session key. After having reconstructed the session key, the subscriber's terminal decrypts the random number and checks matching with its generated random number. The matching between the two numbers allows the verification, by the subscriber, that the access point (2) to which he/she is connecting is not a fake access point.

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METHODS AND SOFTWARE PROGRAM PRODUCT FOR MUTUAL AUTHENTICATION IN A COMMUNICATIONS NETWORK

The present invention relates to a method for authentication in a communications  
5 network, especially a packet, e.g. IP (Internet Protocol), network.

The strong growth in number of Internet users has been one of the most  
remarkable phenomena in communications in recent years. The Internet has born  
and has developed as an "open network", being adapted to share information  
10 between users. Applications, such as the e-mail, the browsing of web pages, the  
download of files, based on Internet communications protocols such as the SMTP  
(Simple Mail Transfer Protocol), the FTP (File Transfer Protocol) or the HTTP  
(Hyper Text Transfer Protocol) are now of common knowledge and used by a  
continuously growing number of users. The Internet technology is being used also  
15 in contexts not open to the public, such as within corporate local area networks, for  
sharing information between employees, in a so-called Intranet environment.  
Recently, the W-LAN (Wireless Local Area Networks) technology is also born and  
is being developed, allowing Internet or Intranet users to connect to the network  
without the need of a cable, by exploiting wireless network terminal adapters and  
20 access points.

In order to connect to the network, a well known technique provides that the user  
gives its credentials in the form of a user-ID and a related password to an  
authentication server, possibly belonging to a service provider. For example,  
25 RADIUS (Remote Authentication Dial-In User Service) is a known server for  
remote user authentication based on a user-ID/password scheme.

Another proposed method for authentication to be performed for accessing a  
network, especially an IP network, is disclosed in the PCT patent application no.  
30 00/02406, in the name of Nokia Networks OY. To allow authentication of users of  
IP networks in a geographically large area, the IP network's terminal uses a  
subscriber identity module (SIM) as used in a separate mobile communications  
system, whereby a response may be determined from a challenge given to the  
identity module as input. The IP network includes a special security server to  
35 which a message about a new user is transmitted when a subscriber attaches to

the IP network. The subscriber's authentication information containing at least a challenge and a response is fetched from the said mobile communications system to the IP network and authentication is carried out based on the authentication information obtained from said mobile communications system by transmitting the  
5 said challenge through the IP network to the terminal, by generating a response from the challenge in the terminal's identity module and by comparing the response with the response received from the mobile communications system. Practically, as disclosed in the same PCT patent application, the authentication method of an existing mobile communications network, especially a GSM (Global  
10 System for Mobile communications) network, is used in an IP network.

Without entering in specific details, a typical authentication procedure used in a mobile communication network, such as a GSM network, provides that when a mobile terminal requires to join the mobile network it first sends the IMSI  
15 (International Mobile Subscriber Identifier), stored on the SIM associated to the mobile terminal, to the network. An Authentication Center (AuC) receives the IMSI number and generates a random number RAND that is inputted to an algorithm dedicated to the authentication (the so-called A3 algorithm). The algorithm is parameterized with an encryption key  $k_i$  uniquely associated to the IMSI number  
20 and, applied to the random number RAND, gives as a result a so-called Signed Response SRES1. The random number RAND is also sent to the mobile terminal, specifically to the SIM associated to the mobile terminal, in order to challenge thereof the generation of a Signed Response SRES2, which is rendered possible from the fact that the SIM stores the same encryption key  $k_i$  and algorithm A3.  
25 SRES2 is then sent to the AuC, that checks a matching between SRES1 and SRES2 in order to grant access in the mobile network to the mobile terminal. If the matching between SRES1 and SRES2 is not verified, the access to the mobile network is denied.

30 The use of the above mentioned authentication procedure for connection to a communications network different from a mobile network, such as the Internet or a corporate Intranet, improves security with respect to a procedure only requiring the provision of a user-ID and a password. For example, a service provider can be substantially assured that the credentials given from the user requiring the  
35 connection are genuine, i.e. that the user is truly one of its subscribers.

However, the Applicant observes that the use of the above mentioned authentication procedure does not guarantee the user in the same way with respect to the service provider, i.e. it does not guarantee the user that he/she is not giving his/her confidential data to a "fake" network, through a fake access point, provided by a malicious entity pretending to be the user's service provider. In particular, the Applicant observes that since the match between the Signed Response SRES1 generated at the AuC and the Signed Response SRES2 generated at the user's SIM is only made at the network side, the user has no way to verify that he/she is actually accessing its trusted network.

The Applicant further observes that such problem is of particular importance accessing networks by exploiting W-LAN technology, in that W-LAN fake access points are relatively easy to be implemented.

The Applicant has faced the problem of implementing an authentication method, particularly adapted for accessing a communications network, more particularly a packet-based (e.g. IP) network, in which a mutual identification can be guaranteed between a subscriber and a service provider in both directions.

The Applicant has found that such problem can be solved by an authentication method in which a random number is generated at the subscriber's terminal. The random number is sent to the authentication sub-system managing the authentication of the subscriber for the access to the network, e.g. together with a subscriber's identifier. At the authentication sub-system, the identifier is used for checking the credentials of the subscriber. During the authentication process, parameters related to the subscriber's identifier are generated at the authentication sub-system, and the random number is encrypted using a session key formed using such parameters. The encrypted random number is then sent back to the subscriber's terminal, together with information needed to terminal in order to reconstruct the session key. After having reconstructed the session key, the subscriber's terminal decrypts the random number and checks matching with its generated random number. The matching between the two numbers allows the verification, by the subscriber, that the access point to which he/she is connecting is not a fake access point.

In a first aspect, the invention relates to a mutual authentication method between a user and a communications network as disclosed in claim 1. Preferred versions of the method of the first aspect are disclosed in claims 2 to 13.

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In a second aspect, the invention relates to a method for allowing a user to verify a trust of a communications network as disclosed in claim 14. Preferred versions of the method of the second aspect are disclosed in claims 15 to 22.

10 In a third aspect, the invention relates to a software program as disclosed in claim 23.

In a fourth aspect, the invention relates to a software program product as disclosed in claim 24.

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In a fifth aspect, the invention relates to an authentication kit as disclosed in claim 25. A preferred embodiment of the authentication kit of the fifth aspect is disclosed in claim 26.

20 In a sixth aspect, the invention relates to a method for allowing a user to verify a trust of a communications network as disclosed in claim 27.

The features and advantages of the invention will be made apparent by the following detailed description of some embodiments thereof, provided merely by way of non-limitative examples, description that will be conducted making  
25 reference to the attached drawings, wherein:

- Figure 1 shows a schematic embodiment of a communications network architecture used in the present invention;
- Figure 2 shows an exemplary exchange of messages taking place between  
30 various network elements during the authentication procedure of the invention.

Figure 1 shows a schematic embodiment of a communications network architecture, in which a remote user connects to an access point 2 in order to gain  
35 access to an IP network 7, for example the Internet. Different access points 2 may

be provided by a service provider to allow network access to different remote users located in different geographical points.

The remote user has a terminal 1, such as a personal computer, for example a portable computer, which carries suitable client software (e.g. a software program based on RADIUS) and hardware adapted to connect to the network 7 through the access point 2. To this purpose, the computer 1 is for example associated to a modem (e.g., an ISDN modem) and exploits a dial-up connection, or an xDSL modem and exploits an xDSL connection, or a GPRS modem and exploits a wireless connection, or a Wireless LAN (WLAN) terminal adapter and exploits a W-LAN connection (such as a WI-FI – Wireless-Fidelity - connection, a kind of Internet access that is becoming popular in areas such as hotels and airports), to the access point 2.

In order to gain access to the network 7, the user is authenticated by the service provider. For authentication purposes, the remote user is provided with a subscriber identity module 1', particularly (albeit not limitedly) a Subscriber Identity Modules (SIM) of the type used for authentication purposes in Digital Cellular phone Systems (DCSs) or Public Land Mobile Networks (PLMNs), such as the widespread Global System for Mobile communications (GSM) mobile phone networks, or known extensions thereof such as the General Packet Radio Service (GPRS) networks (which actually is a sub-network of the GSM network), or Universal Mobile Telecommunications System (UMTS) networks (a wide-band third-generation cellular communication system), or a satellite-based mobile communication network.

As known in the art, a SIM normally takes the form of a card (credit-card size or smaller, depending on the user terminal miniaturization scale), with embedded integrated circuit components, particularly storing personalized data that support SIM's authentication, as well as encryption and decryption. At least up to now, the use of a SIM (and of the SIM-based authentication procedure) for identifying a mobile communication terminal coupled thereto has proven to be a robust way to make it impossible for other devices to impersonate that terminal, thus providing secure authenticated access to, e.g., an account corresponding to that particular user.

The user's SIM 1' is operatively, and preferably removably, coupled to the remote user computer 1; for example, the SIM 1' is embedded in a computer peripheral device that can be operatively coupled to, so as to be functionally accessible by, the computer 1, for example a hardware key connectable to a port (not explicitly shown in Figure 1) of the computer 1, e.g. a Universal Serial Bus (USB) port; alternatively, the SIM 1 may be operatively coupled to the computer 1 through a PCMCIA port thereof, or by means of a peripheral of the smart-card reader type adapted to interact with a SIM and to be coupled to, e.g., a serial port of the computer 1, or the SIM 1' may be embedded in a memory card that can then be operatively coupled to the computer 1 by means of a memory card reader. It is pointed out that the specific way in which the SIM 1' is operatively coupled to the computer 1 is not limitative to the present invention, being in general sufficient that the SIM 1' is operatively coupled to the computer 1 (in a way suitable for enabling communication between the computer 1 and the SIM 1') by means of any type of adapter/reader device connected to the computer 1 through any type of peripheral port. The software client adapted to connect to the network 7, located on the user's personal computer 1, is also adapted to communicate with the SIM 1' coupled to the personal computer 1.

20

The access point 2 is associated to an access node 5 that may comprise a network access server (NAS) 3 and a gateway 4. The access node 5 is operatively connected to an authentication server 6, possibly part, as shown in figure 1, of the mobile network 8 of a mobile operator. The access node 5 is also connected to the network 7 to which the remote user is requiring access, possibly through a proxy server 9, e.g. a firewall, in particular if the network 7 is a private network such as a corporate Intranet.

With reference to the access node 5, it has to be understood that even if figure 1 shows a NAS 3 and a gateway 4 as separate functional entities within the access node 5, in practice they may correspond to suitable software products residing on the same hardware equipment. The NAS 3 may be a router adapted to route traffic directed to and coming from the access points 2. The gateway 4 may be adapted to select where the traffic coming from the access points 2 has to be directed: in particular, during the authentication procedure requested by a remote user

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connected to an access node 2 the traffic coming from the access node 2 is directed towards the authentication server 6 (and vice versa), whereas once the authentication of the remote user has been verified the traffic coming from the access node is directed towards the network 7 (and vice versa).

5

The authentication server 6 is adapted to receive identification information of the remote user, in order to verify that the remote user is a trusted subscriber of the network access service. Furthermore, the authentication server 6 is also adapted to provide the remote user with information suitable for allowing verification, by  
10 the remote user, of the fact that the network to which he/she is connecting is not a fake network, provided by an entity pretending to be his/her service provider. Thus, the whole authentication procedure, that will be explained in detail in the following, allows a mutual authentication between the remote user and the service provider. In preferred embodiments the authentication server 6 is located in the  
15 premises of a mobile network operator and is adapted to communicate with the Home Location Register (HLR) 6' of the mobile network operator, in order to exploit, for the authentication of the remote user, an authentication procedure based on the well-known authentication procedure followed by mobile terminals requesting access to the mobile network. In particular, the HLR 6' of the mobile  
20 network operator includes a database in which an identifier and a key uniquely associated to the remote user are stored. Such identifier and key are also stored on the SIM 1' of the remote user. In other words, the authentication server 6 performs functions similar to those of a Visitor Location Register (VLR) included in the network of a mobile network operator in order to grant or deny access to the  
25 remote user towards the IP network 7: for this reason, the authentication server 6 will be referred in the following as I-VLR 6. The I-VLR 6 may run standard software, such as RADIUS, for controlling at least some steps of the authentication procedure.

30 When requesting access to the network 7, the remote user runs the software client dedicated to control the connection to the access point 2. Figure 2 shows a preferred embodiment of a flux of messages exchanged between the various equipments of the network architecture shown in figure 1.

With reference to figure 2, the software client communicates with the SIM (100) in order to recover (101) a user's identifier, such as the International Mobile Subscriber Identity (IMSI) or the Temporary Mobile Subscriber Identity (TMSI), stored on the SIM. Furthermore the software client generates a number, preferably  
5 a random number Ra, that, as it will be clarified in the following, plays a role in the steps of the authentication procedure required in order to allow the user to authenticate the access point 2 and the network 7 as "trusted". Herein and in the following, the term "number" may be interpreted as any binary, octal, decimal, or hexadecimal number, or even as a generic string of alphanumeric characters.

10

The software client also controls the connection to the NAS 3, through the access point 2. In a step labeled as 102 in figure 2, the software client sends to the NAS 3 the identifier recovered from the SIM and at least a portion of the random number Ra. For example, with specific reference to a connection based on RADIUS, the  
15 identifier IMSI and the random number Ra may be concatenated together in the RADIUS Username field, whereas the RADIUS Password field may be filled with any fixed string (e.g. "SIM\_Auth\_Subs"). In order to increase privacy, the identifier and the random number Ra may be sent in encrypted form. For the purpose of encryption, the user's software client may be comprised of a public key, e.g. a  
20 RSA-based key, provided in advance by the service provider, which in turn retains the related private key. In preferred embodiments, the public key has a length of at least 1024 bits. The connection protocol from the remote user's personal computer 1 and the NAS 3 may further comprise the sending of a domain field, for example in order to allow the NAS 3 to identify different types of connection requests, such  
25 as for example a dial-up request, a xDSL request or a W-LAN request. Advantageously, a single NAS 3 may manage, in such way, different types of connections coming from various types of access points 2, also in case of a connection request coming from an access point of another service provider. Exemplarily, the domain field may be filled with "@wl" identifying a W-LAN  
30 connection or with "@ia", identifying a dial-up connection.

The NAS 3 forwards (as shown by 103 in figure 2) the identifier and the random number Ra to the I-VLR 6. The decryption of the identifier and the random number Ra may be performed at the NAS 3 or, preferably, at the I-VLR 6. The I-VLR  
35 extracts the user's identifier, e.g. the IMSI, and forwards the same (as shown by

104 in figure 2) to the HLR 6'. The HLR 6' (or an Authentication Center, AuC, connected to the HLR 6') comprises a database in which a unique key  $k_i$  is associated to the IMSI. The unique key  $k_i$  is also stored on the SIM 1' of the remote user. In other words, the unique key  $k_i$  represents a shared secret between  
5 the SIM 1' and the authentication sub-system of the network, comprising the I-VLR 6 and the HLR 6' (or the AuC). Following a procedure which is typical for authentication of mobile phones in a mobile telephony network, the HLR 6' (or the AuC) generates a random number Rand1, to which a first algorithm, such as the well known A3 algorithm, parameterized with the unique key  $k_i$ , is applied in order  
10 to obtain a Signed Response SRES1. Furthermore, a second algorithm, such as the well known A8 algorithm, parameterized with the unique key  $k_i$ , is applied to the random number Rand1, in order to obtain a session key  $k_{c1}$ . In other words, the HLR 6' is adapted to obtain at least one triplet of parameters associated to the remote user's identifier, the triplet of parameters being composed by Rand1,  $k_{c1}$ ,  
15 SRES1. In preferred embodiments, at least a second triplet is required to the HLR 6', the second triplet being generated starting from a further random number Rand2 and applying the same procedure as explained above. The second triplet is composed by the further random number Rand2, and by the related further session key  $k_{c2}$  and further Signed Response SRES2. The triplet or triplets is/are  
20 then sent (105) from the HLR 6' to the I-VLR 6.

After receiving the triplet or triplets, the I-VLR 6 encrypts the random number Ra using a further algorithm, such as the well known 3DES algorithm, parameterized with an authentication session key generated by using at least the triplet  
25 parameters, according to a predetermined rule. More particularly, the authentication session key may be the key  $k_{c1}$  or  $k_{c2}$ , or a concatenation thereof, or a concatenation of the keys  $k_{c1}$  and/or  $k_{c2}$  and the signed responses SRES1 and/or SRES2. In preferred embodiments at least a portion of the random number Ra received from the software client may be also concatenated together with the  
30 triplet parameters in order to generate the authentication session key. The concatenation of different parameters obtained from more than one triplet allows to obtain longer authentication session keys, thus permitting a more secure connection between the I-VLR 6 and the user's personal computer 1, which is of particular importance in case of W-LAN connection. For example, the random  
35 number Ra may be encrypted using an authentication session key formed by the

concatenation of  $k_{c1}$ , SRES2,  $k_{c2}$  and Ra8, wherein Ra8 are the first 8 digits of the random number Ra. A further random number TID (or a portion thereof), generated by the I-VLR 6, may be also encrypted with the authentication session key together with the random number Ra. Such further random number TID may  
5 be a transaction identifier, identifying at the I-VLR 6 the particular connection session initiated by the remote user's personal computer 1. After encryption of the random number Ra, and possibly of the random number TID, the encrypted frame, together with the random numbers Rand1 and Rand2 (the latter in case two triplets were obtained by the HLR 6'), is sent (106) to the personal computer 1, i.e.  
10 to the software client controlling the network connection.

The random numbers Rand1 and Rand2, that were obtained by the HLR 6', are then sent to the SIM (107) from the client software, in order to challenge the SIM to produce the related keys  $k_{c1}$ ,  $k_{c2}$  and signed responses SRES1, SRES2, using  
15 the stored unique key  $k_i$ .

The SIM then provides (108) the obtained parameters to the software client. Using the parameters obtained by the SIM, the software client may reconstruct the authentication session key, in a manner corresponding to that used by the I-VLR,  
20 in order to decrypt the encrypted frame received from the I-VLR 6. The rule according to which the authentication session key is reconstructed by the software client is the same used by the I-VLR. After having reconstructed the authentication session key, the software client can extract the Ra number received from the I-VLR 6 and compare the same with the random number Ra self-generated at the  
25 beginning of the procedure. The matching of the two Ra numbers allows verification, by the software client (i.e., by the user), that the connection service through which the personal computer 1 is connecting to the network 7 is trusted. In other words, the user has the possibility to "authenticate" the connection service.

30 In order to complete the authentication procedure, the software client forwards (109) to the I-VLR 6 at least one of the signed responses SRES1 or SRES2 generated by the SIM, possibly encrypted with the authentication session key. The transaction identifier TID may be also encrypted together with the signed response or responses, and sent to the I-VLR 6. The I-VLR 6 then checks matching between

the signed response or responses locally generated and the signed response or responses generated by the SIM 1'.

5 If the matching among the signed responses is verified, an accept request message is sent (110) to the software client, allowing access to the network 7. Possibly, a register message is sent (111) to the proxy server 9 in order to allow use of IP services (such as HTTP, FTP, SMTP, and so on) to the remote user. In such way, the service provider, furnishing the connection service to the user, authenticates the user.

10

On the other hand, if the matching among the signed responses is not verified, a reject request is sent (112) to the software client from the I-VLR 6. A stop accounting message may be also sent (113) to the NAS 3 from the I-VLR 6, in order to instruct the NAS 3 to interrupt communications with the personal  
15 computer 1.

The above disclosed authentication procedure of a remote user's terminal for access to a network service thus allows a mutual authentication between the remote user and the network service. Advantageously, such mutual authentication  
20 improves security for all connections, including connections implying portions using radio connection paths, such W-LAN connections. Such mutual authentication allows the service provider to recognize the remote user, and also allows the remote user to recognize the service provider, so that confidential information from the remote user cannot be captured by a hacker setting up a fake  
25 service provided through a fake access point. Furthermore, as explained above, the authentication procedure may be advantageously set up so as to use the same protocol for different connection types, and even for managing connection requests coming from access points belonging to different service providers.

30 It has to be understood that actual operations identified in the above described procedure may be implemented in suitable software code portions of computer programs, and carried out by any well-known general purpose computer having appropriate processing abilities, as it will appear to those skilled in the art. In particular, the description of the processing steps enables those skilled in the art to

realize computer program codes appropriate to particular contexts and facilities, such as particular machines, computer languages, operating systems and the like.

Software programs realized according to the teachings of the present invention  
5 can be for example embodied in one or more executable files resident on suitable support accessible from the memory of the computer, such as a hard disk, a diskette, a CD- or DVD-ROM, or an external disk readable through a LAN. For the purposes of the present invention, the terms "software (or computer) program adapted to be loaded into the memory of a computer" also comprise files needed  
10 for the execution of the executable file or files, such as libraries, initialization files and so on, that can be resident on a suitable support accessible from the memory of the computer, such as a hard disk, a diskette, a CD-ROM or an external disk readable through a LAN. Furthermore, for the purposes of the present invention the terms "software program" also comprise files possibly different from the  
15 executable file or files and/or from the files needed for the execution of the same, embodied in an installable software, adapted, when run on the computer, to install the executable file or files and the files needed for the execution of the same. Such installable software can be resident on a suitable support, such as a diskette, or a CD-ROM or it can be available for download from a network resource, such as a  
20 server comprised in a LAN or reachable through an external network, for example the Internet.

**CLAIMS**

1. A method for a mutual authentication between a user and a communications  
5 network, said user being provided with a terminal (1) to which a subscriber  
identity module (1') is operatively coupled, said subscriber identity module  
storing at least one identifier and a first copy of a unique key associated to said  
user, said network including an authentication sub-system (6,6') comprising at  
least a first authentication apparatus (6') storing a second copy of said unique  
10 key associated to said user identifier, said method comprising,
- sending said user identifier from said subscriber identity module (1') to  
said terminal (1);
  - generating, at said terminal (1), a first number;
  - sending said identifier and at least a portion of said first number from  
15 said terminal (1) to said authentication sub-system (6,6'), through an  
access point (2) of said network;
  - at said authentication sub-system (6,6'), identifying said second copy of  
said unique key using said identifier, generating at least a second  
number and challenging said second number with said second copy of  
20 said unique key, so as to generate at least a first session key and at  
least a first signed response;
  - at said authentication sub-system (6,6'), forming, according to a first  
rule, a second session key using at least said first session key, and  
encrypting at least said first number portion using said second session  
25 key;
  - sending at least said encrypted first number portion and said second  
number from said authentication sub-system (6,6') to said terminal (1);
  - forwarding said second number from said terminal (1) to said  
subscriber identity module (1'), and challenging, at said subscriber  
30 identity module (1') said second number with said first copy of said  
unique key, so as to generate at least a third session key and at least a  
second signed response;
  - sending said third session key and said second signed response from  
said subscriber identity module (1') to said terminal (1);

- at said terminal (1), forming a fourth session key, according to a second rule corresponding to said first rule, using at least said third session key, and decrypting said first number portion received from said authentication sub-system (6,6') using said fourth session key;
  - 5 - checking, at said terminal (1), a matching between said decrypted first number portion with a corresponding portion of said generated first number, so as to allow communications from said network to said terminal (1);
  - sending at least said second signed response from said terminal (1) to  
10 said authentication sub-system (6,6');
  - at said authentication sub-system (6,6'), checking a matching between said first signed response and said second signed response, so as to allow communications from said terminal (1) to said network.
- 15 2. A method according to claim 1, characterized in that it further comprises encrypting said identifier and said first number portion at said terminal (1), before said step of sending from said terminal (1) to said authentication sub-system (6,6'), said encryption being performed with a predetermined public key, stored on said terminal (1).
- 20 3. A method according to claim 2, characterized in that it further comprises decrypting said identifier and said first number portion at said authentication sub-system (6,6'), said decryption being performed with a private key related to said predetermined public key.
- 25 4. A method according to any one of claims 1 to 3, characterized in that said first rule for forming said second session key comprises concatenating said first session key and said first signed response.
- 30 5. A method according to claim 4, characterized in that said second rule for forming said fourth session key comprises concatenating said third session key and said second signed response.
- 35 6. A method according to any one of claims 1 to 5, characterized in that said step of encrypting, at said authentication sub-system (6,6'), at least said first



number portion using said second session key comprises encrypting also a transaction identifier generated at said authentication sub-system (6,6').

- 5 7. A method according to claim 6, characterized in that said step of decrypting, at said terminal (1), said first number portion received from said authentication sub-system (6,6') using said fourth session key also comprises decrypting said transaction identifier.
- 10 8. A method according to claim 7, characterized in that it further comprises sending said decrypted transaction identifier from said terminal (1) to said authentication sub-system (6,6').
- 15 9. A method according to any one of claims 1 to 8, characterized in that it further comprises generating, at said authentication sub-system (6,6'), at least a third number and challenging said third number with said second copy of said unique key, so as to generate at least a fifth session key and at least a third signed response.
- 20 10. A method according to claim 9, characterized in that said first rule for forming said second session key comprises concatenating at least one among said first session key and said first signed response with at least one among said fifth session key and said third signed response.
- 25 11. A method according to claim 9 or 10, characterized in that said step of sending at least said encrypted first number portion and said second number from said authentication sub-system (6,6') to said terminal (1) further comprises sending said third number to said terminal (1).
- 30 12. A method according to claim 11, characterized in that it further comprises challenging, at said subscriber identity module (1'), said third number with said first copy of said unique key, so as to generate at least a sixth session key and at least a fourth signed response.
- 35 13. A method according to claim 12, characterized in that said second rule for forming said fourth session key comprises concatenating at least one among

said third session key and said second signed response with at least one among said sixth session key and said fourth signed response.

14. A method for allowing a user to verify a trust of a communications network, the user being provided with a terminal (1) to which a subscriber identity module (1') is operatively coupled, said subscriber identity module storing at least one identifier and at least one unique key associated to said user, said network including an authentication sub-system (6,6'), said method comprising, at said terminal (1):
- 10       - receiving said user identifier from said subscriber identity module (1');  
      - generating a first number;  
      - sending said identifier and at least a portion of said first number to said authentication sub-system (6,6'), through an access point (2) of said network;
  - 15       - receiving from said authentication sub-system (6,6'), through said access point (2), an encrypted number and at least a second number generated at said authentication sub-system (6,6');
  - forwarding said second number to said subscriber identity module (1');
  - 20       - receiving, from said subscriber identity module (1') at least a first session key and a first signed response, obtained at said subscriber identity module (1') from a challenge on said second number with said unique key;
  - generating a second session key using at least one among said first session key and said first signed response, according to a predetermined rule;
  - 25       - decrypting said encrypted number received from said authentication sub-system (6,6') using said second session key;
  - checking a matching between said portion of said first number with a corresponding first portion of said decrypted number, so as to allow trust verification of said network.
  - 30
15. A method according to claim 14, characterized in that it further comprises encrypting said identifier and said first number portion at said terminal (1), before said step of sending from said terminal (1) to said authentication sub-

system (6,6'), said encryption being performed with a predetermined public key, stored on said terminal (1).

- 5 16. A method according to claim 14 or 15, characterized in that said predetermined rule for forming said second session key comprises concatenating said first session key and said first signed response.
- 10 17. A method according to any one of claims 14 to 16, further comprising sending said first signed response to said authentication sub-system (6,6').
18. A method according to claim 17, further comprising sending a second portion of said decrypted number to said authentication sub-system (6,6')
- 15 19. A method according to any one of claims 14 to 19, characterized in that it further comprises receiving, from said authentication sub-system (6,6'), at least a third number generated at said authentication sub-system (6,6').
- 20 20. A method according to claim 19, characterized in that it further comprises forwarding said third number to said subscriber identity module (1').
- 25 21. A method according to claim 20, characterized in that it further comprises receiving, from said subscriber identity module (1') at least a third session key and a second signed response, obtained at said subscriber identity module (1') from a challenge on said third number with said unique key.
- 30 22. A method according to claim 21, characterized in that said predetermined rule for forming said second session key comprises concatenating at least one among said first session key and said first signed response with at least one among said third session key and said second signed response.
- 35 23. A software program loadable into a memory of a computer, comprising software code portions for performing the steps of any one of claims 14 to 22, said computer program product being adapted, when run on a computer, to outputting information suitable for allowing a user to verify a trust of a communications network to which said user is connecting.

24. A software program product comprising a support accessible from a memory of a user's terminal, on which the software program according to claim 23 is stored.
- 5
25. An authentication kit for authenticating a user's terminal (1) in a communications network, comprising a software program product according to claim 24 and a subscriber identity module (1').
- 10
26. A kit according to claim 25, characterized in that said subscriber identity module (1') is of a type adopted in mobile communication networks for authenticating mobile communication terminals.
- 15
27. A method for allowing a user to verify a trust of a communications network, the user being provided with a terminal (1), with an identifier and with a shared secret, said network including an authentication sub-system (6,6') storing said user's identifier associated to a copy of said shared secret, said method comprising, under control of said terminal (1):
- generating a first number;
  - 20 - sending said user's identifier and at least a portion of said first number to said authentication sub-system (6,6'), through an access point (2) of said network;
  - receiving from said authentication sub-system (6,6'), through said access point (2), an encrypted number, said encrypted number being encrypted with a session key generated at said authentication sub-system (6,6') based on said copy of said shared secret and on a second number generated at said authentication sub-system (6,6');  
25
  - receiving from said authentication sub-system (6,6'), through said access point (2), said second number;
  - 30 - processing said second number and said shared secret so as to obtain a copy of said session key;
  - decrypting said encrypted number received from said authentication sub-system (6,6') using said copy of said session key;

- checking a matching between said portion of said first number with a corresponding portion of said decrypted number, so as to allow trust verification of said network.

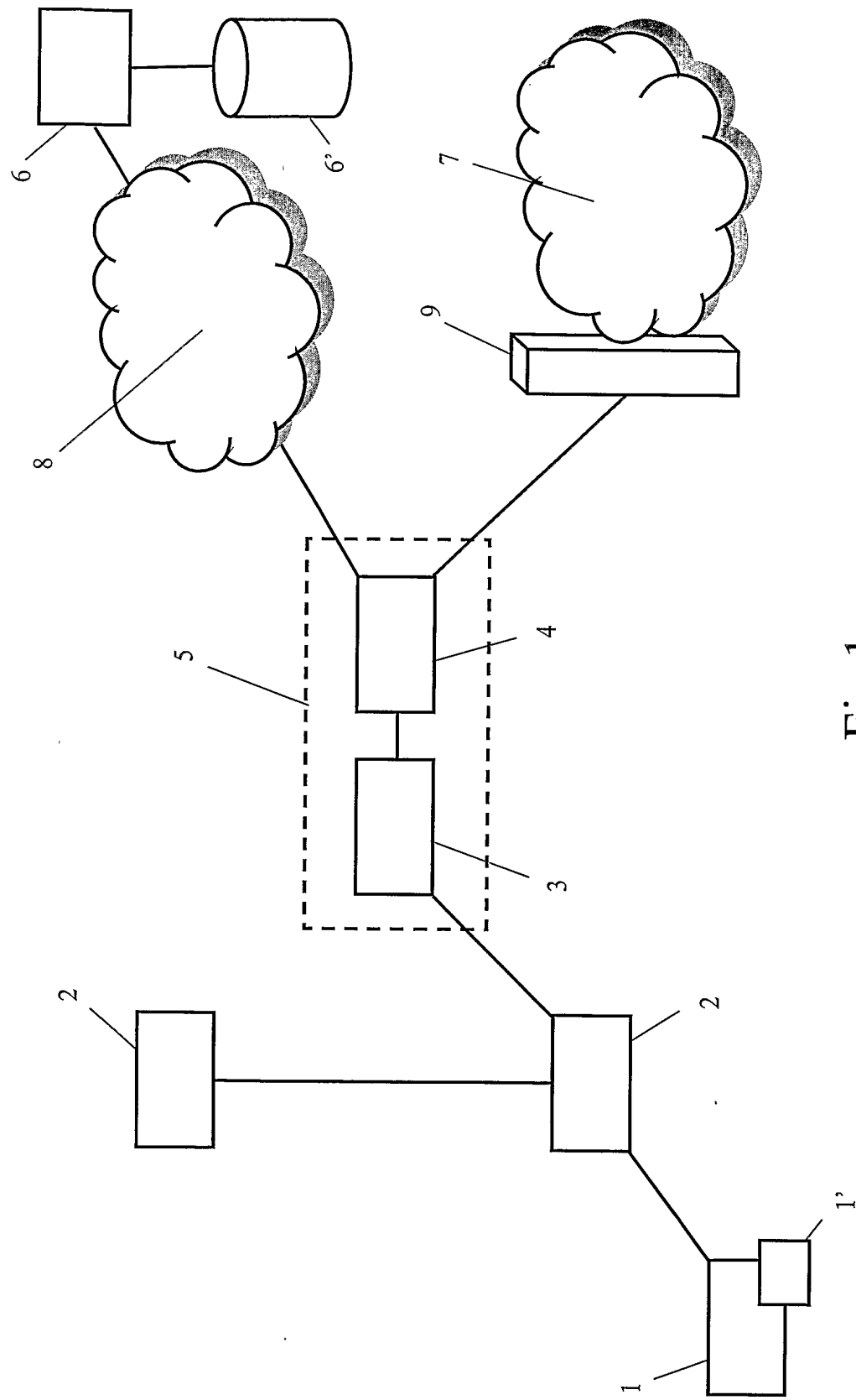


Fig.1

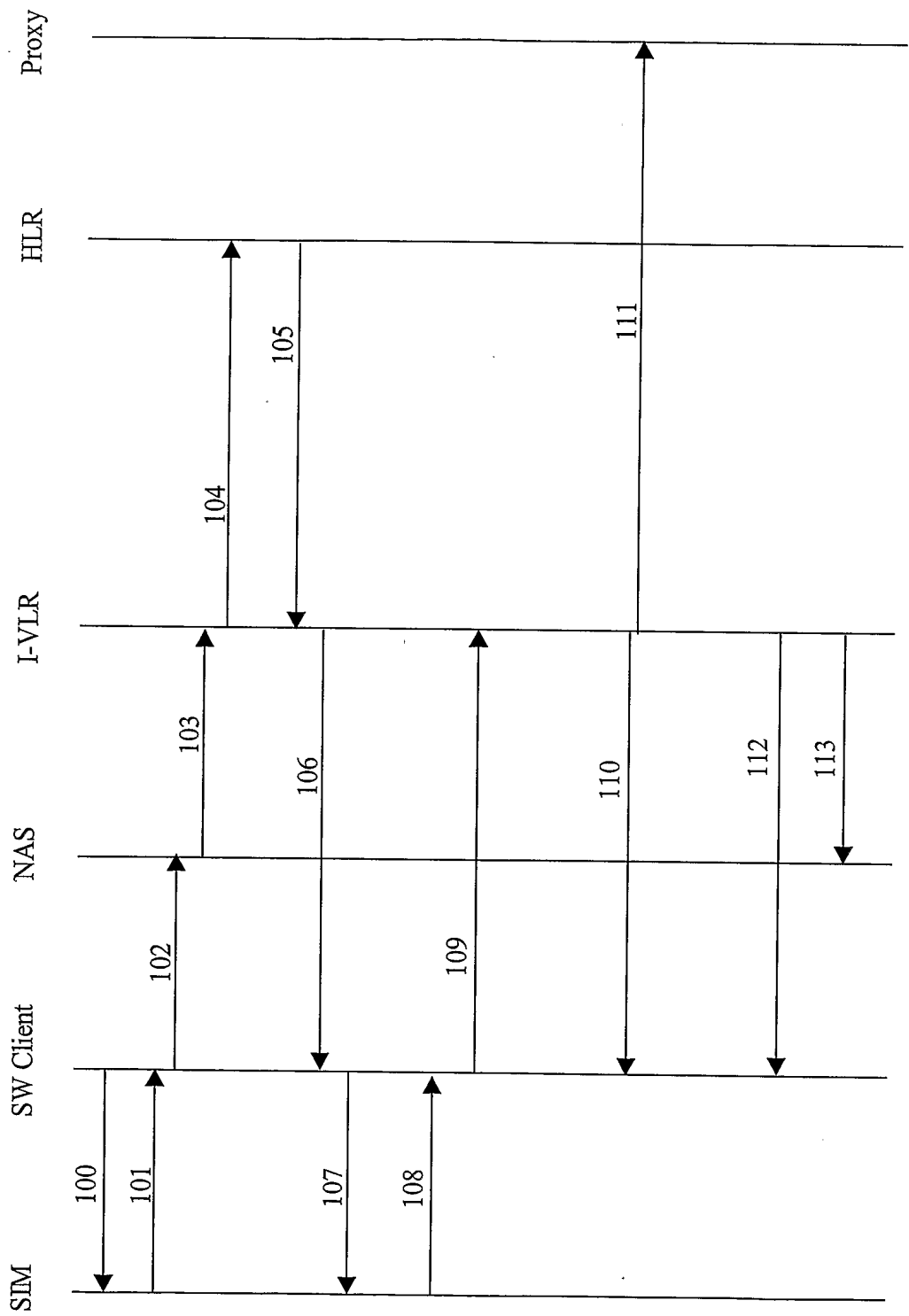


Fig.2

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP2004/002307

A. CLASSIFICATION OF SUBJECT MATTER  
 IPC 7 H04L29/06 H04L12/28 H04L12/56

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>WO 02/052784 A1 (NOKIA NETWORKS OY ;            EKBERG JAN ERIK (FI))            4 July 2002 (2002-07-04)            page 2, line 4 - page 12, line 24; figures            1-3,6,8,9            page 19, line 24 - page 29, line 14            -----            -/--</p>	1-27



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

19 July 2004

Date of mailing of the international search report

06/08/2004

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## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/EP2004/002307

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>3GPP SA: "Universal Mobile Telecommunications System (UMTS); 3G security; Security architecture (3GPP TS 33.102 version 5.1.0 Release 5); ETSI TS 133 102"</p> <p>ETSI STANDARDS, EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE, SOPHIA-ANTIPO, FR, vol. 3-SA3, no. V510, December 2002 (2002-12), XP014010200 ISSN: 0000-0001 paragraph '006.! - paragraph '6.3.7.!</p>	1-27
A	<p>ALPEROVICH V, PUTHENKULAM J, WALKER J, LORTZ V: "EAP SIM GMM AUTHENTICATION (draft-buckley-pppext-eap-sim-gmm-00.txt)" IETF INTERNET DRAFT, August 2002 (2002-08), pages 1-30, XP015000396 Retrieved from the Internet: URL:www.ietf.org&gt; paragraph '001.! - paragraph '4.1.!</p>	1-27
A	<p>HAVERINEN H, SALOWEY J: "EAP SIM Authentication (draft-haverinen-pppext-eap-sim-10.txt)" IETF INTERNET DRAFT, February 2003 (2003-02), pages 1-58, XP015001142 Retrieved from the Internet: URL:www.ietf.org&gt; paragraph '019.! - paragraph '19.11!</p>	1-27
A	<p>WO 00/02406 A (NOKIA NETWORKS OY ; EKBERG JAN ERIK (FI)) 13 January 2000 (2000-01-13) cited in the application page 1, line 1 - page 16, line 24; figure 6</p>	1-27

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP2004/002307

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			JP	2002520923 T		09-07-2002
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**PUB-NO:** WO2004079985A1  
**DOCUMENT-IDENTIFIER:** WO 2004079985 A1  
**TITLE:** METHOD AND SOFTWARE PROGRAM  
PRODUCT FOR MUTUAL  
AUTHENTICATION IN A  
COMMUNICATIONS NETWORK  
**PUBN-DATE:** September 16, 2004

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MARCELLI MAURIZIO	IT

**APPL-NO:** EP2004002307

**APPL-DATE:** March 5, 2004

**PRIORITY-DATA:** ITRM20030100A (March 6, 2003)

**INT-CL (IPC):** H04L009/06 , H04L012/28 , H04L012/56

**EUR-CL (EPC):** H04L029/06 , H04L029/06

**ABSTRACT:**

CHG DATE=20040928 STATUS=O>A method for mutual authentication between a subscriber and a communications network, in which a random number is generated at the subscriber's terminal (1, 1'). The random number is sent to the authentication sub-system (6, 6') managing the authentication of the subscriber for the access to the network, e.g. together with a subscriber's identifier. At the authentication sub-system, the identifier is used for checking the credentials of the subscriber. During the authentication process, parameters related to the subscriber's identifier are generated at the authentication sub-system, and the random number is encrypted using a session key formed using such parameters. The encrypted random number is then sent back to the subscriber's terminal, together with information needed to terminal in order to reconstruct the session key. After having reconstructed the session key, the subscriber's terminal decrypts the random number and checks matching with its generated random number. The matching between the two numbers allows the verification, by the subscriber, that the access point (2) to which he/she is connecting is not a fake access point.